

University of Maryland
Department of Geographical Sciences
Syllabus
GEOG 498I/ 788I Spring 2018

Instructor

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Office hours: 2:00-3:00pm Tuesday and Thursday, or by appointment

Classes: 12:30pm – 1:45pm Tuesday / Thursday LeFrak Hall 1171

Course Description

The aim of the course is to familiarize the student with the fundamentals of GIS algorithms. These algorithms are often aided by the use of spatial indexes. We will explore how different indexes effect the efficient execution of these algorithms which can be substantial. We will also explore algorithms for performing network operations such as shortest path or connectivity analysis. In addition, we will look at operations on social networks and at the interplay between the methods that they use and the effect of embedding these networks in a spatial network. The algorithms that we discuss will be based on both vector and raster representations. Some of the operations that we will discuss include point-in-polygon, range queries, shortest path, connectivity analysis, and nearest neighbors. These algorithms find use in geographic information systems, in spatially-based decision systems, and location-based services. Special attention will be paid to the manipulation and analysis of terrain models, as well as scalable algorithms and representations for big geospatial data. Students with some programming background will highly benefit from this course.

Prerequisites

Students with programming background in a declarative language such as Python, Java, C or C++, will highly benefit from this course.

Course learning objectives

The aim of the course is to familiarize the student with the fundamentals of geospatial algorithms, and techniques for encoding, manipulating and querying geospatial data as well as networks. The students will gain a deep understanding of the underlying geospatial and network algorithms which will allow them to use and enhance existing spatial data bases, geographic information systems as well as tools for social network analysis. Moreover, the students will learn how to design and implement algorithms and suitable representations for dealing with geospatial entities and networks which scale to big data.

Lecture material: Course notes in the form of slides posted on Canvas

Recommended Books

- N. Xiao, *GIS Algorithms*, 2016, SAGE Publications (basic reference book for the class)
- M. Goodrich, R. Tamassia, Goldwasser, *Data Structures and Algorithms in Python*, 2013, Wiley and Sons (algorithms with an introduction to Python).
- H. Samet, *Foundations of Multidimensional and Metric Data Structures*, 2006, Morgan Kaufmann Publishers (spatial algorithms and representations)

Grading

- **Mid-term exam** – 25%
- **Lab assignments** – 10%
- **Project (or research paper)** – 30%
- **Final exam** – 25%
- **Class participation** – 10%

The course includes two non-cumulative exams: one mid-term exam, and one final exam. Although the exams are not cumulative, understanding of the notions and principles acquired in earlier parts of the course will be necessary to answer exam questions in the later parts of the course. All exams will present a combination of questions requiring the definitions of specific representations or the description of some techniques all seen in class and described in detail in the course notes. Class participation will include occasional short quizzes and other in-class activities.

The Lab assignments will consist of developing programs, in Python or any declarative language the student is familiar with, implementing some data structures and algorithms seen in class. The project consists of the design and the development algorithms for answering spatial queries on point data. The project for graduate students will have an extra-part which will be defined by an individual consultation with the instructor. An alternative to the project for all students will be a research paper which will have to be presented in class. The topic of the research paper will be defined individually with the instructor. Extra effort on the research papers will be required from the graduate students.

Tentative Schedule

- **January 25:** Introduction to the course
- **January 30:** Review of basic data structures: lists and arrays
- **February 1:** Examples of implementations in a programming language (Python)
- **February 6:** Basic spatial entities. An example of a spatial algorithm: point-in-polygon algorithm
- **February 8:** Lab class: implementing the point-in-point algorithm
- **February 13:** Fundamentals of binary trees and binary tree traversals
- **February 15:** Binary search trees and basic queries
- **February 20:** Lab class on binary search trees
- **February 22:** Query operations on point data and applications
- **February 27:** Quadtrees: definitions, examples and encoding
- **March 1st:** Point location and point insertion in a quadtree
- **March 8:** Neighbor finding on a quadtree
- **March 8:** Project presentation in class
- **March 13:** Review for the midterm exam
- **March 16:** **Midterm exam**
- **March 27:** Point data representation through kD trees
- **April 3:** Networks: definitions, properties
- **April 5:** Networks: basic data structures

- **April 10:** Path computation on networks; applications to road networks
- **April 12:** Connectivity and centrality computations; applications to social network analysis
- **April 17:** Representations for polygonal maps
- **April 19:** Polygonal maps: query algorithms (point location, map overlay)
- **April 24:** Terrain models: raster versus vector-based models (Triangulated Irregular Networks-TINs)
- **April 26:** Representations for TINs – Lab class
- **April 30:** How to build a TIN from elevation data
- **May 3:** Distributed data structures for big spatial data: point data
- **May 7:** Distributed data structures for big spatial data: terrain data
- **May 10:** Preparation for the final exam

General Requirements

Requirements for this course include attendance and participation in the lectures, completion of programming assignments and/ or a research paper, a midterm exam, and a final exam. Course readings will come from a comprehensive set of slides posted by the instructor, which will form the course notes. The students are strongly urged to attend and participate in all lectures since this will provide a basic understanding of the subject matter of the course. Lectures will also include information not present in the posted notes. The exams will be based on all material presented in the lectures and on any required reading.

Students are expected to treat each other with respect. Disruptive behavior of any kind will not be tolerated. Students who are unable to demonstrate civility with one another, the teaching assistants, or the instructor will be subject to referral to the Office of Student Conduct or to the University Campus Police. Students are expected to adhere to the Code of Student Conduct.

Academic Integrity

The University of Maryland, College Park has a nationally recognized Code of Academic Integrity, administered by the Student Honor Council. This Code sets standards for academic integrity at Maryland for all undergraduate and graduate students. Students are responsible for upholding these standards for this course. It is very important for a student to be aware of the consequences of cheating, fabrication, facilitation, and plagiarism. Students are strongly advised to visit <https://bsosundergrad.umd.edu/engagement/academic-integrity-honorf> for more information. The Honor pledge must be included in every assignment and exam submitted by the students: "I pledge on my honor that I have not given or received any unauthorized assistance on this assignment/paper/examination."

Students with Disabilities

Every effort will be made to accommodate students who are registered with the Disability Support Service (DSS) Office and who provide the instructor with a University of Maryland DSS Accommodation form. This form must be presented to the instructor at the beginning of classes and no later than February 14, 2017. The instructor will not be able to accommodate students who are not registered with DSS or who provide the instructor with documentation which has not been reviewed and approved by UM's DSS Office.

Medical Excuses

Any student who needs to be excused for an absence from a single lecture, recitation, or lab due to a medically necessitated absence shall: a) Make a reasonable attempt to inform the instructor of his/her illness prior to the class. b) Upon returning to the class, present their instructor with a self-signed note attesting to the date of their illness. Each note must contain an acknowledgment by the student that the information provided is true and correct. Providing false information to University officials is prohibited under Part 9(i) of the Code of Student Conduct (V-1.00 (B) University of Maryland Code of Student Conduct) and may result in disciplinary action.. Any student who needs to be excused for a prolonged absence (2 or more consecutive class meetings), or for a Major Scheduled Grading Event, must provide written documentation of the illness from the Health Center or from an outside health care provider. This documentation must verify dates of treatment and indicate the timeframe that the student was unable to meet academic responsibilities. In addition, it must contain the name and phone number of the medical service provider to be used if verification is needed. No diagnostic information will ever be requested.

Exam Make Up Policy

The instructor is not under obligation to offer a substitute assignment or to give a student a make-up assessment for missing a Major Scheduled Grading Event unless the failure to perform was due to an excused absence. A valid excused absence will need to be granted through the student presenting documentation from the Health Center or from an outside health care professional. This documentation must be submitted within one week of returning to classes and must include dates of incapacitation as well as the name and phone number of the health care provider. No diagnostic information shall be given. Once the period of incapacitation is over, the student must meet the missed academic responsibilities according to the requirements and specification set forth by the instructor.

CourseEvalUM

Participation in the evaluation of courses through CourseEvalUM is a responsibility of the student hold as a member of our academic community. The feedback is confidential and important to the improvement of teaching and learning at the University as well as to the tenure and promotion

process. The date from which CourseEvalUM is open to complete evaluations will be announced by the University. Please go directly to the website (www.courseevalum.umd.edu) to complete evaluations by the requested date. By completing all the evaluations each semester, a student will have the privilege of accessing online, at Testudo, the evaluation reports for the thousands of courses for which 70% or more students submitted their evaluation.

